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A People-First Gait Analysis Device: Bringing Sensor-Based Gait Assessment into Everyday Care

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ABSTRACT

We present a novel wearable device for routine gait monitoring in both indoor and outdoor environments. Although there exist traditional gait assessment devices (e.g. gait mats and motion capture systems) that provide highly accurate gait data, they are not practical for day-to-day monitoring due to their technical complexity and limited spatial range. There have been efforts to simplify gait monitoring by using wearable sensors, but they either do not capture all gait parameters (i.e. inertial devices) or require patient-specific customization (i.e. instrumented insoles).

This device offers a practical alternative to other solutions for routine gait assessment that encompasses simplicity (ease of use) and clinical value (usefulness). This is achieved by means of an instrumented one-size-fits-all shoe cover with an accompanying graphical user interface (GUI). For the shoe cover, criteria such as durability, size-adjustability, and ease of donning and doffing (accessibility) were used to verify a successful design. A two-piece design with separate forefoot and heel sections makes the device both adjustable and accessible. The primary material is neoprene, making it durable for different terrains and whose elasticity ensures it fits over various shoe sizes. The GUI is developed using Python and enables clinicians to collect data via Wi-Fi. The GUI provides all key spatiotemporal parameters in addition to interactive plots of approximate ground reaction forces and is designed to be intuitive and seamless, ensuring the clinician focuses on data interpretation.

The shoe cover features nine sensors: one inertial measurement unit (IMU), one time-of-flight distance sensor (ToF), and seven force-sensing resistors (FSR). The temporal parameters are calculated using established algorithms using heel-strike and toe-off timings, which are extracted from both the FSR and IMU data. Spatial parameters, such as step width and stride length, are calculated using a Kalman filter which consolidates IMU and ToF sensor data. The Kalman filter estimates acceleration, velocity, and position, making it simple to visualize gait trajectory.

The shoe cover is validated using commercially available gait monitoring equipment such as a gait mat (i.e. GaitRITE) and instrumented insoles (i.e. loadsol). This ensures the algorithms employed to calculate spatiotemporal values are accurate. Further validation is done through interviews with gait clinicians in which they assess the overall functionality of the system and the likelihood of using it to complement traditional gait monitoring techniques. With this device, we aim to provide clinicians with an option for gait monitoring that is simple to use and provides clinical value.